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TECHNICAL REPORT M-279
May 1980

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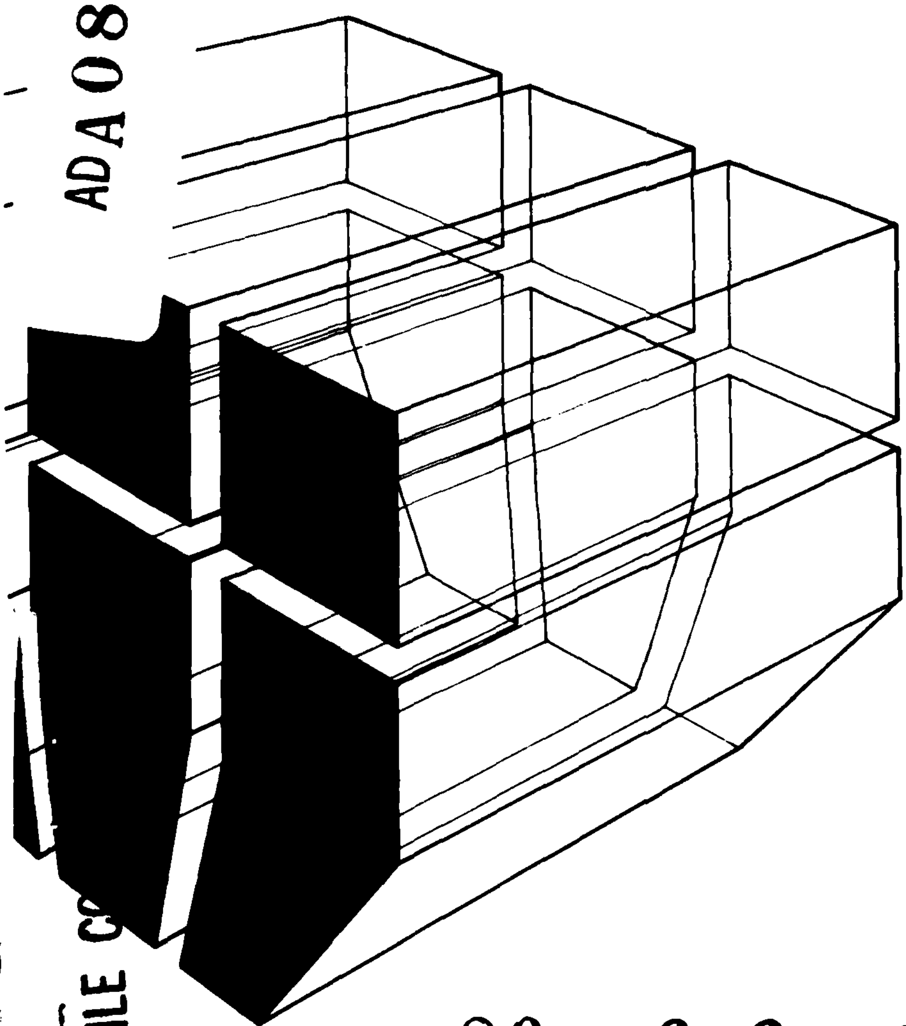
ROOFING REPAIR MATERIALS FOR KOREAN RELOCATABLE BUILDINGS—TEST AND EVALUATION



by
Robert E. Muncy

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER (14) CERL-TR-M-279	2. GOVT ACCESSION NO. AD-A085 188
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) (6) ROOFING REPAIR MATERIALS FOR KOREAN RELOCATABLE BUILDINGS — TEST AND EVALUATION	5. TYPE OF REPORT & PERIOD COVERED (9) FINAL repts
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Robert E. Muncy	8. CONTRACT OR GRANT NUMBER(s) IAO No. FED 3-80
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005, Champaign, IL 61820	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (12) 17
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE (11) May [redacted]80
	13. NUMBER OF PAGES 15
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

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Springfield, VA 22151

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

roofs
repair

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report presents the results of tests of two commercial roof repair materials, Contourflash and Polyseal, to determine how they would perform in the roof repair of Army relocatable barracks in Korea. All tests were conducted with the existing roof sealant in place.

FOREWORD

This investigation was conducted for the Far East Division (FED), U.S. Army Corps of Engineers, at the request of the Pacific Ocean Division (POD), under Intra-Army Order (IAO) No. FED 3-80. The Point of Contact at POD was Mr. A. D. Sameshima.

The work was performed by the Engineering and Materials (EM) Division, U.S. Army Construction Engineering Research Laboratory (CERL). Dr. G. R. Williamson is Chief of EM.

COL L. J. Circeo is Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director.

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ROOFING REPAIR MATERIALS FOR KOREAN RELOCATABLE BUILDINGS—TEST AND EVALUATION

1 INTRODUCTION

Background

Two hundred and forty "relocatable" panel barracks, each 24 × 48 ft (7.3 × 14.6 m), were built at U.S. Army installations in Korea during FY75 and FY76. The roofs on these barracks were designed for panel-to-panel connections; through the years, the environment has begun to affect the soft sealant exposed in these connections, causing leaks to develop in some roofs. These leaks are sometimes enlarged when troops walk on the roofs.

In January 1980, the Corps of Engineers' Pacific Ocean Division (POD) asked the U.S. Army Construction Engineering Research Laboratory (CERL) to evaluate two potential roof repair materials: Contourflash and Polyseal.* Both materials are compounded forms of chloroprene (neoprene) rubber. Contourflash is supplied in sheet form and is designed to cure slowly after application. Polyseal is a trowel-applied mastic from which solvent evaporates, leaving solid material which cures into a rubber.

Objective

The objective of this study was to evaluate the potential of Contourflash and Polyseal as roof repair materials for Army relocatable barracks in Korea.

Approach

1. The effects of temperature changes and live loads on the roofs of relocatable buildings were simulated.

2. The effects of temperature on the repair materials and the adhesive bond to the metal roof panels were determined.

3. The effects of ultraviolet exposure on cured Contourflash and Polyseal were examined.

*Contourflash is a product of Gaco Western, Inc., P.O. Box 88698, Seattle, WA; Polyseal is a product of the Monroe Company, Inc., 30801 Carter Street, Cleveland, OH.

Scope

This study was limited to the two material systems specified to CERL by POD.

Safety

The solvents contained in Contourflash and Polyseal should not adversely affect personnel when used in an adequately ventilated area. Since some of the solvent materials are flammable, a "no smoking" or "no open flame" policy should be used during application.

2 TEST PROGRAM AND RESULTS

Both Polyseal and Contourflash were evaluated based on how they performed when applied over the existing roof sealant, a material called Superseal.

Specimen Preparation (Substrate)

Each specimen was prepared using two 4 × 4 in. (101.6 × 101.6 mm) coupons taken from roof panels similar to those in actual use on roofs in Korea. All coupons were 0.025-in. (0.635-mm)-thick painted embossed aluminum loosely attached to 1/2-in. (12.7-mm) plywood. The coupons' surfaces were prepared by first washing the painted aluminum, then cleaning it by rubbing lightly with a clean cloth and xylene, a grease and oil solvent.

Test Materials

The Polyseal was applied by trowelling a strip about 1/4 × 6-1/2 in. (6.35 × 165.1 mm) thick over a 4-in. (10.6-mm)-wide strip of Superseal. A 1-in. (25.4-mm)-wide bond breaker of teflon tape was placed on the Superseal before the Polyseal was applied (Figure 1). The tape was centered over the length of the panel joint. These specimens were later used for tensile strength, elongation, and cyclic stretching tests. Because it was difficult to trowel and smooth the Polyseal, all Polyseal test specimens (Figure 2) were of uneven material thickness.

Contourflash specimens were 4 in. (101.6 mm) wide × 7 in. (177.8 mm) long and were prepared in three ways:

1. The bonding area of each coupon was coated with Gaco Western epoxy E-5320 and allowed to cure overnight at room temperature. Contact cement (Gaco N-7R) was then applied to both the epoxy-primed area and the Contourflash. The solvent from the contact

Figure 1. Bond breaker.

Figure 2. Polyseal adhesion specimen.

cement was allowed to evaporate for about 30 minutes, then a 1-in. (25.4-mm)-wide strip of teflon tape was placed over the joint and the surfaces were bonded together (Figure 3).

2. Another group of Contourflash specimens were prepared exactly as described above, except Gaco Western epoxy E-5320 was not used.

3. The adhesion test specimens were prepared by applying a 4-in. (101.6-mm)-wide strip of Contourflash to a 4 X 4 1/2 in. (101.6 X 114.3 mm) coupon. After curing, the rubber was slit into 1-in. (25.4-mm)-wide strips. No difficulty in applying the material was experienced with either procedure.

Curing

The Polyseal specimens were cured at a room temperature of about 70°F (21.1°C) for 48 hours. The specimens were then placed in an oven and heated to 150°F (65.6°C) for 72 hours, and to 200°F (93.3°C) for 16 hours. (The Superseal did not appear to be affected by sustained elevated temperatures.)

The Contourflash specimens were cured at about 70°F (21.1°C) for 24 hours, then placed in an oven and heated to 150°F (65.6°C) for 72 hours, and to 200°F (93.3°C) for 16 hours.

Cyclic Loading Tests

Tests were conducted at low and high temperatures (-40 and 165°F [-40 and 73.9°C], respectively) to determine (1) the ability of Polyseal and Contourflash to withstand elongation, (2) the quality of their adhesive bond to the aluminum, and (3) their durability under cyclic loading. The equipment setup for the endurance test is shown in Figure 4; the setup for the elongation test is shown in Figure 5.

For the loading tests, cyclic loading at a frequency of 1 cycle/second (cps) and a stroke of 3/8 in. (9.5 mm) was used. The stroke was selected to be about the same as the maximum movement during extreme temperature changes.

Polyseal Cyclic Loading Tests

Six Polyseal specimens (labeled PS-1, PS-2, etc.) were subjected to cyclic loading.

Specimen PS-1 was tested at -25°F (-31.7°C) and 1 cps for 450 cycles; the PS-1 test was continued as the chamber temperature increased from -25 to 45°F (-31.7 to 7.22°C), at which time 1850 cycles had been completed. The test continued as the temperature gradually rose to 60°F (15.6°C). A total of 8000 cycles were completed. The temperature rise occurred because of a loss of cooling capacity, a condition that was subsequently corrected. The test was terminated with no visible discontinuities. It was noted that the elongation recovery of the Polyseal specimens at -25°F (-31.7°C) was not complete within each cycle.

PS-1 was later tested at 165°F (73.9°C) and 1 cps; the material recovered almost completely during each cycle. After 600 cycles at this new temperature, the adhesion bond near one edge of the specimen began to fail; i.e., it pulled away from the aluminum. The PS-1 test was discontinued after 685 cycles when the Polyseal completely separated from one of the aluminum coupons.

Specimen PS-2 was tested at -40°F (-40°C) for 270 cycles, at which time repeated localized bending caused the thin aluminum facing to break.

Specimen PS-3 was tested at -40°F (-40°C). At 660 cycles, a 3/4-in. (19.05-mm)-long tear started near the center of the PS-3 specimen over the coupon joint. A small tear became visible at the right edge of the specimen after 760 cycles (Figure 6). After 850 cycles, the tape (bond breaker) was visible through the Polyseal and the test was discontinued.

Specimen PS-5 was tested at -40°F (-40°C). A tear became visible at 800 cycles; at 1150 cycles, the tear extended halfway across the specimen. However, when the test was terminated at 1930 cycles, the tear still was not completely across the material (Figure 7).

Specimen PS-6 was tested at -40°F (-40°C). The first 10 cycles were run at 100 seconds/cycle and the material recovered completely at this loading/unloading rate. The test was completed by switching the rate to 1 cps, and after 100 cycles, the aluminum failed by bending.

Contourflash Cyclic Loading Tests

Three Contourflash specimens (labeled C-1, C-2, and C-3) were evaluated for cyclic loading performance.

Specimen C-1 was tested at -39°F (-39.4°C) for 1090 cycles with no failure. The test was continued by increasing the temperature from -39 to 0°F (-39.4 to -17.8°C); at 1806 cycles there was no failure. A final extension of the test from 0 to 30°F (-17.8 to

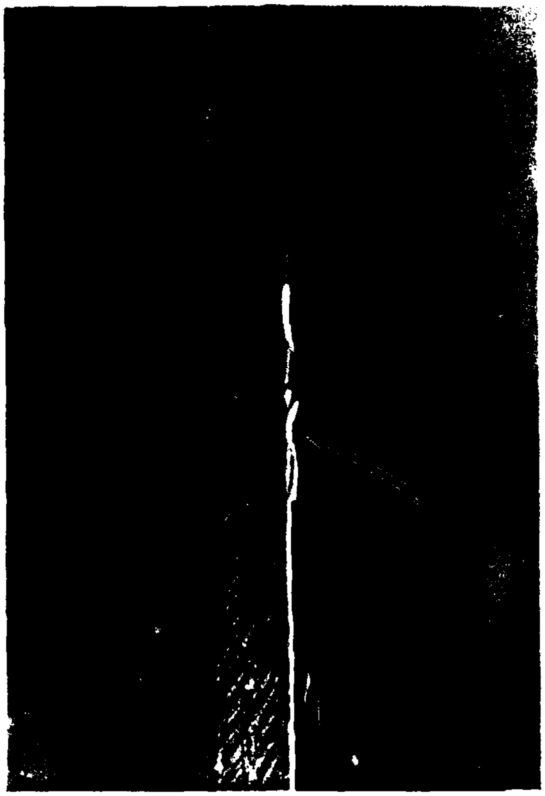

Figure 3. Bondbreaker under Contourflash.

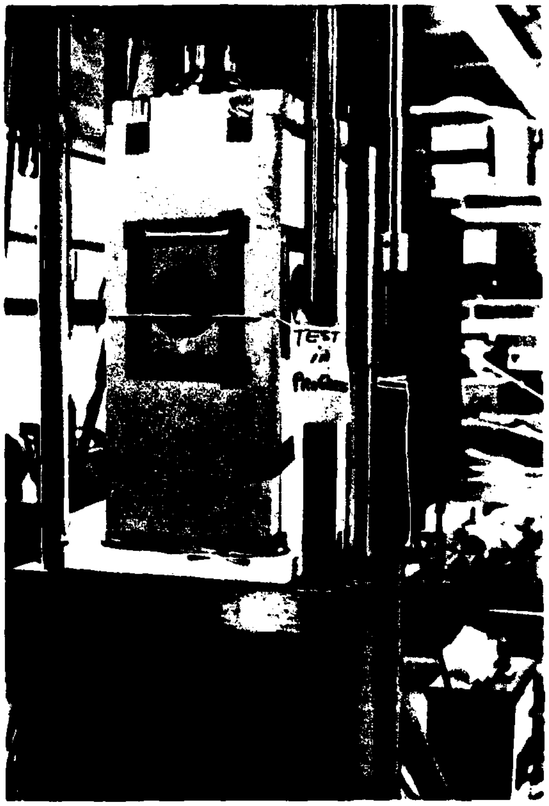

Figure 4. Adaptation of test machine for temperature control.

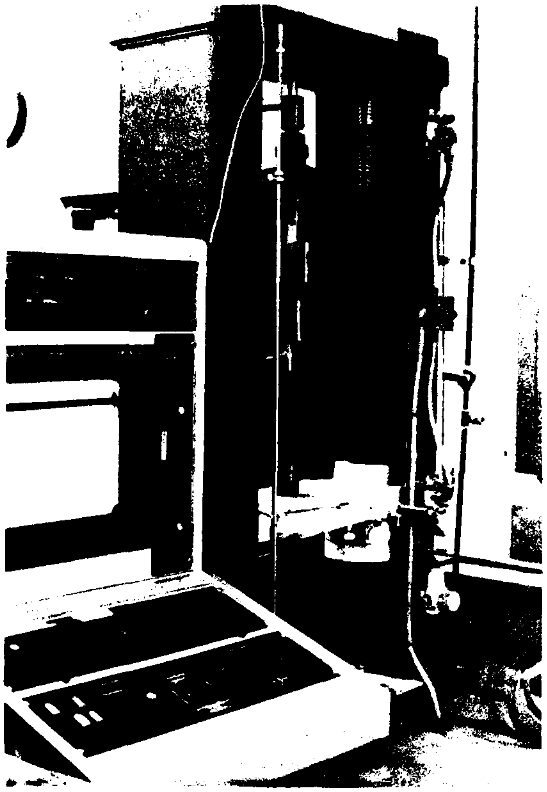

Figure 5. Tensile test machine.

Figure 6. Tear in Polyseal (arrow).

1.1°C) and 3206 cycles produced no visible discontinuities or failure.

Specimen C-2 was tested at -38°F (-38.8°C) to 4000 cycles with no failure. The test was extended by increasing the temperature from -38 to -8°F (-38.8 to -22.2°C) for 5035 cycles; there was no failure.

Specimen C-3 was tested at 165°F (73.9°C) for 6000 cycles with no visible discontinuities.

Displacement in all three Contourflash tests was 3/8 in. (9.5 mm) (Figure 8).

Tensile Strength and Elongation Tests

In the tensile strength and elongation tests, a load rate of 1 in. (25.4 mm) per minute was used. One Polyseal and four Contourflash specimens were tested. Contourflash coupons C-6 and C-7 (Figure 9) used a backer rod to increase the length of material that was not bonded to the substrate and that could, therefore, be involved in stretching. The test results are described below.

Coupon C-4, tested at about -40°F (-40°C), had a tensile strength greater than 880 psi (5.06 MPa) and elongation greater than 1 in. (25.4 mm) (more than 100 percent) before adhesive bond slippage began. Coupon C-4 was prepared using N-7R adhesive plus E-5320 epoxy.

Coupon C-5, tested at about -40°F (-40°C), had a tensile strength greater than 1160 psi (27.99 MPa) and elongation greater than 1 in. (25.4 mm) (more than 100 percent) before adhesive debonding from the aluminum began. This specimen did not include the epoxy primer.

Coupons C-6 and C-7 were tested at 70°F (21.1°C) and both had an elongation greater than 1 in. (25.4 mm) (100 percent) and tensile strengths of greater than 520 and 680 psi (3.5 and 4.68 MPa), respectively. The inclusion of the backer rod did not significantly add to the performance of the material.

Coupon PS-7 (Polyseal) was tested at -40°F (-40°C); it showed a tensile strength greater than 760 psi (5.2 MPa) and a total of 1-5/8 in. (41.3 mm) (160 percent) elongation before failure (Figure 10). All elongation test specimens experienced lap shear failure in the adhesive bond. The failure proceeded as a line from the joint toward the grip ends of the coupons.

Hardness Tests

Hardness tests were performed in accordance with ASTM D 2240-75 using a Shore A-2 Durometer tester.[1] The results were:

Contourflash	Polyseal
Hardness of 90 at -40°F (-40°C)	Hardness of 95+ at -40°F (-40°C)
Hardness of 70 at 70°F (21.1°C)	Hardness of 80 at 70°F (21.1°C)
Hardness of 68 at 74°F (23.3°C)	Hardness of 60 at 74°F (23.3°C)

The increase in hardness at the low temperature is normal and suggests the approach of the temperature at which the material would be brittle.

Adhesion Tests

Adhesion tests were performed in accordance with ASTM D 429-73.[2] The results of these tests are described below.

1. Polyseal at 70°F (21.1°C): All four test specimens failed at 5 lb/in. (2.27 kg/25.4 mm) of width and failed at the Polyseal-paint interface.

2. Contourflash with N-7R adhesive only at 70°F (21.1°C):

Result	Comment
Specimen 1: 8 lb/in. (3.64 kg/25.4 mm) of width	Adhesive pulled away from painted metal surface
Specimen 2: 9 lb/in. (4.09 kg/25.4 mm) of width	
Specimens 3, 4: 12 lb/in. (5.45 kg/25.4 mm) of width	

3. Contourflash with N-7R adhesive plus E-5320 epoxy tested at 70°F (21.1°C):

Result	Comment
Specimen 1: 14 lb/in. (6.36 kg/25.4 mm) of width	Separation was within the N-7R layer
Specimen 2: 13 lb/in. (5.9 kg/25.4 mm) of width	
Specimen 3: 13-1/2 lb/in. (6.14 kg/25.4 mm) of width	

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[1] *Rubber Property–Test for Durometer Hardness*, ASTM D 2240-75 (American Society for Testing and Materials [ASTM], 1973).

[2] *Rubber Property–Tests for Adhesion to Rigid Substrates*, ASTM D 429-73 (ASTM, 1975).

Figure 7. Enlarged tear in PS-5.

Figure 8. Maximum gap between test coupons.

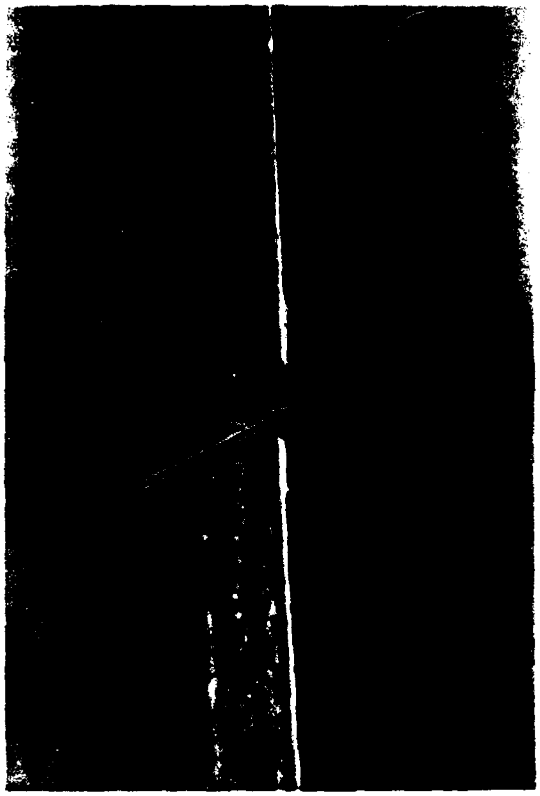

Figure 9. Backer rod of foam.

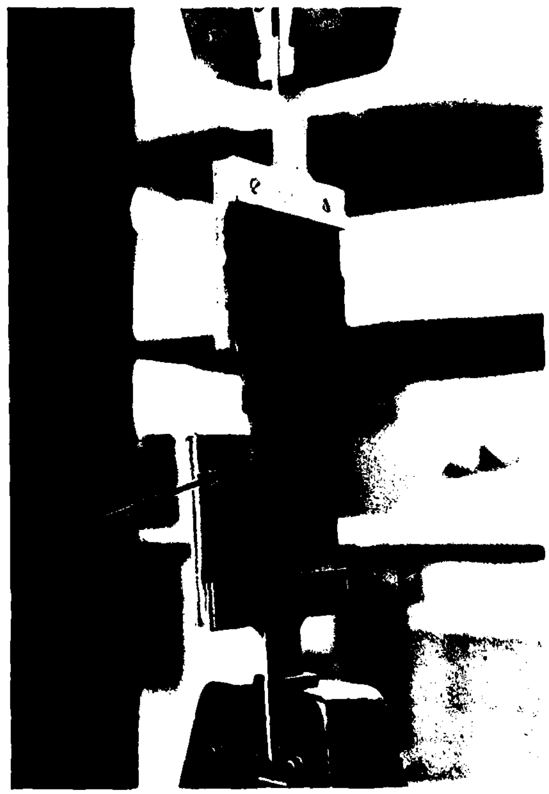

Figure 10. Typical failure of repair material adhesion.

Ultraviolet Exposure

Four samples (two Contourflash, two Polyseal) were prepared and subjected to ultraviolet light and water condensation for 1224 hours. An Atlas UV-Con system was set at a 50 percent ultraviolet -50 percent condensation cycle for the test. A slightly sooty discoloration of the Contourflash was noted; this discoloration could not be removed by rubbing it lightly by hand. A hardness reading was taken at 70°F (21.1°C) using the Shore A-2 Durometer. The Contourflash samples registered a hardness value of 76; the Polyseal samples recorded a value of 80. These results indicated a slight increase in hardness of the Contourflash under the conditions and no observable hardness change in the Polyseal. The slight hardness change in the Contourflash was not regarded as significant.

3 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Cyclic Loading

Five of the six Polyseal test specimens subjected to different cyclic loading rates and different temperatures failed or exhibited discontinuities. None of the three Contourflash specimens tested failed or exhibited discontinuities.

Tensile Strength and Elongation

The Polyseal specimen exhibited a tensile strength greater than 760 psi (5.2 MPa) before failure. The Contourflash specimens exhibited tensile strengths ranging from greater than 520 psi (3.5 MPa) at 70°F (21.1°C) to 1160 psi (27.99 MPa) at -40°F (-40°C).

Elongation in the Polyseal specimen was greater than 1-5/8 in. (41.3 mm) or more than 160 percent. Elongation in the Contourflash specimens was greater than 1 in. (25.4 mm) or more than 100 percent in all tests.

Hardness

Polyseal specimens had a hardness of more than 95 at -40°F (-40°C), 80 at 70°F (21.1°C), and 60 at 74°F (23.3°C). Contourflash specimens had a hardness of 90 at -40°F (-40°C), 70 at 70°F (21.1°C), and 68 at 74°F (23.3°C).

Adhesion

All Polyseal test specimens failed at 5 lb/in. (2.27 kg/15.4 mm). Contourflash specimens with N-7R adhesive failed at 8, 9, and 12 lb/in. (3.64, 4.09, and 5.45 kg/25.4 mm); the Contourflash specimen with E-5320 epoxy failed between 13 and 14 lb/in. (5.9 and 6.36 kg/25.4 mm).

Ultraviolet

Exposure to ultraviolet light and water condensation produced an insignificant increase in the hardness of the Contourflash specimens; there was no observable change in Polyseal hardness during the tests.

Recommendations

1. A minimum bonding area 2 in. (50.8 mm) wide should be allowed on each side of the existing Superseal when the repair material is applied.

2. Special attention should be paid to the surface preparation and the application of the repair material. The quality of these two features is critical to obtaining satisfactory long-term leak protection.

3. Personnel should be kept off relocatable panel barrack roofs except for required work, and then only with load-spreading walkways in place.

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Muncy, Robert E.
Roofing repair materials for Korean relocatable buildings : test and evaluation. -- Champaign, IL : Construction Engineering Research Laboratory ; Springfield, VA : available from NTIS, 1980.
15 p. (Technical report ; M-279)

1. Roofs -- maintenance and repair. I. Title. II. Series: U.S. Army Construction Engineering Research Laboratory. Technical report ; M-279.